PROGRESS REPORT No. 1
NASA GRANT NGR-09-003-007 The American University
"Analysis of the Direct Current Arc"

June 1965 - December 1965

1. The work performed to date on this grant has been directed primarily toward the development of instrumentation for precise and accurate measurement of the arc operating data. These data include:

    a. Temperature difference between inlet and outlet water of both anode and cathode
    b. Arc voltage and current
    c. Electrode separation
    d. Anode and cathode water flow rate

2. The primary standards to be used to calibrate the instrumentation are:

    a. Potential: Leeds and Northrup Type K Potentiometer (with unsaturated standard cell)
    b. Temperature: NBS calibrated Bomb Calorimeter thermometer.
    c. Volume: NBS calibrated flask.

The references used to determine standardization procedures are:

    a. Precision Measurement and Calibration, Volumes 1, 2, 3. (NBS Handbook 77)
    b. Calibration and Test Services (NBS Publication 250)
    c. Handbook of Electrical Measurements (Instruments Publication Co.)
    d. Temperature: Its Measurement and Control in Science and Industry, Volumes 1, 2, 3 (Reinhold)
    e. Quality Control System Requirements (MIL-Q-9858-A)
    f. Calibration System Requirements (MIL-C-45662A)
    g. Information obtained from the Thermometer Calibration Section of NBS

The types of systems considered for measurement of the water temperature were:

    a. Potentiometric recorder with thermocouple sensors.
    b. Resistance measuring recorder with thermistor sensors.
    c. Resistance measuring recorder with platinum resistance sensors
    d. Digital readout amplifier with crystal sensors.

The following companies were contacted for information regarding their temperature measuring and recording equipment:

a. Westronics, Inc: Potentiometric and resistance measuring recorders.
b. Electronic Marketing Associates: Varian Recorders
c. Kipp and Zonen: Recorders
d. Mitsui and Co., Ltd: Recorders
e. Hewlett Packard: Quartz Thermometer
f. Minneapolis Honeywell Regulator Co.: Recorders
g. Leeds and Northrup: Recorders

The equipment finally selected and purchased was an L and N Speedomax W potentiometric recorder and 9835-A DC Pre-amplifier for use with thermocouple sensors. This set of equipment was judged the best to meet the accuracy requirements of the project. The thermocouple-potentiometric recorder system was selected over the others because the relatively small size of the thermocouple sensors permits their insertion directly in the narrow passages of the cooling water stream. The L and N recorder has the additional and very useful feature of adjustable zero, adjustable range controls.

4. Thermocouple sensors were fabricated by resistance heating in inert gas or by welding in inert gas. Fittings were designed for water-tight insertion of the sensors into the water streams close to the active regions of the anode and cathode. Difficulties are still being encountered in adequately insulating the thermocouples to prevent electrical breakdown when the high voltage arc starter is employed. Polyethylene insulating tubing of very small diameter will be tried.

5. A range change kit and a new slide-wire scale were obtained for our department Honeywell Brown Electronik recorder. This change was made to increase the accuracy of the recorder for measurement of the arc voltage and current.

6. Our new HW-18 torch (a gift of Linde Company) was exchanged for an HW-10 model. This model, long out of production, is better cooled and more suited to research needs. The old torch was improved and modified as follows:

a. Machined new O-ring seats to make gas-tight.
b. Machined new one-piece collet holder.
c. Machined new split torch handle to allow for thermocouple insertion.
d. Obtained kit of spare parts.

7. Work done on the torch-anode apparatus stand:

   a. New anode heat exchanger designed and fabricated.
   b. New anodes prepared using oxygen free copper.
   c. Vibration isolators installed under stand.
   d. New vernier control designed and fabricated for precise electrode separation adjustment.
   e. Arc starter relocated as close as possible to the stand and rewired.

8. Other equipment obtained during the reporting period includes:

   a. Bomb Calorimeter thermometer
   b. Helium tank and gas filling
   c. Oxweld R-503 Helium Regulator and Flowmeter
   d. Beckman differential thermometer
   e. Two-liter volumetric flask

9. Visits were made to:

   a. Goddard Space Flight Center - Mr. Charles Duncan
   b. Bioenergetics Laboratory, U.S. Naval Hospital - Dr. T.H. Benzinger

10. Visits to the project were:

   a. Mr. Charles Duncan - GSFC, Greenbelt, Maryland
   b. Mr. R.A. Beall - Metallurgy Research Center, Bureau of Mines, Albany, Oregon

11. In addition to the measurement standard references mentioned in Paragraph 2, we have obtained reference material on current government-sponsored arc research and solar simulation research through STAR and Aerospace Abstracts.

12. Work to be accomplished in the next reporting period will include:

   a. Design of a cooling water temperature control. This control is needed to adjust the incoming water temperature to a temperature slightly less than the room temperature.
   b. Design of a telecentric optical system for projection of the arc image onto a screen for viewing and photographing.
   c. Obtain arc operating data in argon atmosphere using tungsten cathodes of various diameters and oxygen-free copper anode.

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